~~V-5977~~

DPSP 79-17-17

V 5449 ✓

CC: R. Maher, 703-A
J. H. Hershey, 704-F
D. C. Nichols, 704-2F
T. L. Davis, 704-1H
D. B. Jett, 704-1H
R. W. Yancey, 704-1H
B. S. Johnson, 706-1H
C. W. Swindell, 706-1H
G. H. Street, 706-2H
H. H. Elder, 706-1H
J. C. Bailey, 706-1H
W. L. West, 706-1H
L. R. Austin, 679-G
E. J. Majzlik, 679-G (2)
J. A. Gentilucci, 704-H
Tech File, 706-1H
PRD Record Copy, 703-A

V5449

File Code: SEP-WM-301.1.5

June 29, 1979

TO: O. M. MORRIS

FROM: C. COMLY, IV CC IV

PRD
RECORD COPY

TANK 16 DEMONSTRATION
MULTIPUMP TEST RESULTS

SUMMARY AND CONCLUSIONS

Long-shaft pumps were installed in risers 2, 4A, and 8 of tank 16 to determine the minimum number of pumps required to slurry all the sludge in a waste tank. Figure 2 shows the equipment arrangement. Operation of two pumps (in risers 2 and 8) did not slurry all the sludge. Operation of three pumps (in risers 2, 4A, and 8) slurried material throughout the tank, but a 450 square foot pile of sludge was left under riser 3. Additional slurrying, with pump discharges directed at this pile, removed all but several small scattered piles. About 1.8% of the original 77,000 gallons of sludge remained after multipump testing.

These results indicate only three or four pumps of the type used will be required per tank (depending on tank type) for hydraulic cleaning versus the seven to nine pumps per tank predicted in earlier studies. Because fewer pumps are required, no risers will have to be cut in the tank tops. Operating problems with the pumps were minimal. No excessive tank top deflection was detected.

Based on reliable performance during the demonstration, the tank 16 long-shaft pump design is considered a satisfactory candidate for use in the waste removal program. Some improvements in the design are desirable to reduce seal water leakage and to facilitate decontamination.

Operating data for tank 16 and associated facilities during the tests are included in this report.

DISCUSSION

Test Details

Two multipump slurries reduced the amount of sludge in tank 16 to 1400 gallons, 1.8% of the estimated initial 77,000 gallons. Thirty-six percent of the tank 16 sludge was removed during earlier testing of a single slurry pump in riser 2.[4] Periscopic inspection showed the sludge farther than thirty feet from that slurry pump was relatively undisturbed (see Figure 1). Throughout the demonstrate the volutes of the slurry pumps were above the waste after the slurry was transferred to minimum heel. Fluid addition was then required to prime the pumps. Before the multipump tests began, 16,200 gallons of supernate was added to tank 16 to fill the crater left after one-pump testing and submerge the riser 2 slurry pump volute.

On January 30, the pumps in risers 2 and 8 were started. Seventy hours later, unslurried sludge was visible on the western side of tank 16, the maximum distance from the pumps. The slurry pump in riser 4A was started and slurrying continued for 94 more hours. The resulting slurry (27 volume % solids) containing 48% of the original sludge was transferred to tank 15. The cumulative percentage of sludge transferred was 83%.

All three pumps were operated for 76 hours for the second multipump test after the addition of 38,000 gallons of priming supernate. The slurry was transferred, leaving 1.8% of the original sludge. Transfer data are summarized in Table 1.

The sludge remaining after each test was in two forms: relatively undisturbed solid sludge piles and slurried sludge in the liquid pump heel. After the first multipump slurry transfer, a pile remained more than 40 feet from the riser 2 pump. This same area was more than 28 feet from the riser 4A pump (see Figure 1). The pump in riser 4A had not been operated as long as the other pumps and did not slurry all the sludge within its influence. The pile's elevation increased from six inches high at its edges to 18-20 inches at its center. It covered 450 square feet, 8% of the tank bottom, and contained 3600 gallons of the 12,900 gallons of sludge remaining in tank 16 at that time. In the first multipump test each operating slurry pump had been rotated on a turntable at 1/5 rpm with its direction reversed every two to four hours. In the second multipump test, the discharge nozzles of pumps in risers 2 and 4A were alternately aimed at the pile to aid in slurrying. The pump in riser 8 was aimed at an area under the valve house that was more than 30 feet from any pump; that area could not be inspected because of obstructions by valve house piping. After the second multipump test, the only visible sludge was in several small piles underneath riser 3. These piles were about four inches high and covered 1% (sixty square feet) of the tank bottom. Of the 1380 gallons of sludge estimated to remain in tank 16, only 150 gallons was unslurried in piles.

Sample analyses for the multipump slurries are reported in Tables 2 and 3. Estimates of the amount of sludge in a slurry was based on the volume percent solid analyses. Solids content of unslurried tank 16 sludge was estimated at 70.2% based on material balances.

Heat Balance

Tank cooling coils[5] were valved in service during the first but not during the second multipump test. Average tank liquid temperature during the first multipump test is plotted in Figure 2. The temperature increased 2°C and equilibrated at 30°C with two pumps running. When the third pump was started, the temperature equilibrated at 32°C. The heat removed by the cooling coils was ∿6000 Btu/min.

Tank liquid temperature rose from 26°C to 51°C during the second multipump test when all three slurry pumps were operating (see Figure 3). The rate of temperature rise decreased, indicating an equilibrium was approached.

Using the apparent ambient soil temperature of 14.4°C found for the one-pump test, the calculated heat transfer rate to the environment for the second multipump test was 20,700 Btu/hr -°C.[6]

Tank 16 Ventilation

While no significant hydrogen concentration was detected in the tank vapor, large humidity increases were observed during slurrying (see Figure 4). Purge flow rate varied from 445 to 471 cfm. Activity in the ventilation systems of tank 16, tank 15, and diversion box HDB-2 was not excessive (see Table 4). Other operating data are summarized in Table 5.

Leak Detection

No leakage into the annulus of tank 16 was observed. The annulus conductivity probes did not alarm. No level was indicated by the annulus dip tubes. Ground water sampled around tank 16 showed no increase in activity during the demonstration (see Figure 5). Radiation from the transfer line during the first multipump transfer is shown in Figure 6.

Slurry Settling

The slurries were removed with a transfer pump through an agitated pump tank to another type II tank, tank 15. Initial laboratory data from slurry samples from tank 16 indicate a slow settling rate (see Table 6). Further testing is underway at SRL and in tank 15 to more accurately determine the settling rate.

Pump Performance

The slurry pumps described in Reference 1 performed well. At the start of the first multipump test, the pumps could only run as high as ∿1700 rpm (versus 1800 maximum) because of high motor amperage. As the viscosity of the slurry decreased, pump speed was increased to maximum. Average seal water leak rate per operating pump was 1.9 gpm for the first multipump test and 2.1 gpm for the second multipump test. As a precaution, seal water was inhibited to prevent tank and coil corrosion.

The transfer pump is described in Reference 1. Transfer data are listed in Table 7. Because the transfer pump was throttled near the end of the second multipump test transfer and the slurry was less viscous than previous slurries, the heel depth was lowered to 2.15 inches.

A slurry pump was moved from riser 8 to riser 6 for the next phase of the demonstration, water washing and acid cleaning, to allow installation of a rotary spray in riser 8. Radiation and contamination data collected during the pump relocation are shown in Figure 7.

REFERENCES

1. Hill, A. J. Removal of Sludge from High Activity Waste Tanks, DP-1093, July 1967.

2. Bradley, R. F., et al., A Low-Pressure Hydraulic Technique for Slurrying Radioactive Sludges in Waste Tanks, DP-1468, November 1977.

3. Hill, A. J., and F. A. Parsons, Technical Data Summary - Removal of Sludge and Chemical Cleaning of Tank 16-H, DPSTD-241-TK-16H, February 15, 1977.

4. West, W. L., Tank 16 Demonstration Single-Pump Test Reults, DPSP 79-17-12, April 26, 1979.

5. W-163012, W-163593.

6. Comly, C., Waste Removal Program Calculations, DPSON-242.

CC:mfh

TABLE 1

TANK 16 SLUDGE REMOVAL TESTS

Test Type	Single-Pump		Multipump	
Run No.	1	2	1	2
Hours run by pump #2	86	208	168	76
#4A	-	-	94	76
#8	-	-	169	76
Sludge volume before test, gal.	77,000			
Flush water added before test, gal.	8,000	27	172	297
Flush water added during test, gal.	0	0	0	0
Seal water added during test, gal.	8,993	12,793	49,265	29,282
Supernate added, gallons				
First addition	-	22,458	16,199	37,661
Second addition	-	6,995	-	-
Slurry transferred to tank 15, gallons	22,085	56,450	97,475	75,065
Flush of line to tank 16, gal.	27	172	297	300
Flush of line to tank 15, gal.	1,606	2,940	3,185	2,633
Vol. % solids in slurry, based on 1 hr. centrifuging	37	20	27	11.3
Sludge transferred, gal.	11,550	15,631	36,883	11,550
Sludge remaining, gal.	65,450	49,919	12,936	1,386
Percent sludge removed	15.0	20.3	47.9	15.0
Cumulative percent sludge removed	15.0	35.3	83.2	98.2

TABLE 2

TANK 16 FIRST MULTIPUMP TEST
SAMPLE ANALYSES

Sampling Time, Hours from Startup	26	50	50	122	160	171
Riser No.	1	1	4	1	4	4
Density, g/ml	1.31	1.38	1.31	1.31	1.32	1.29
Volume % Solids, 1 hr. centrifuging[1]	31	28 & 32	36	30 & 31	27	25 & 28
Viscosity, cp at viscometer spindle speed of:						
5 rpm	-	1,300	-	1,760	1,306	1,220
10 rpm	-	700	-	950	750	650
20 rpm	-	375	-	500	400	350
50 rpm	-	180	-	240	190	176
100 rpm	-	110	-	140	110	100
Tank Volume, gallons	77,300	84,000	84,000	103,600	113,200	15,225[2]

Notes:

[1]After 1 hour at 2800 rpm in an IEC Damow centrifuge.

[2]After transfer of slurry.

TABLE 3

TANK 16 SECOND MULTIPUMP TEST
SAMPLE ANALYSES

Sampling Time, Hours from Startup	24	48	72.5
Riser No.	5	5	5
Density, g/ml	1.34	1.29	1.28
Volume % Solids*	11.3 & 11.6	11.6	11.3 & 11.6
Viscosity, cp at viscometer spindle speed of:			
5 rpm	100	100	100
10 rpm	100	60	60
20 rpm	50	45	50
50 rpm	30	30	30
100 rpm	30	28	29
Tank Volume, gal.	73,150	74,900	82,950

*After 1 hour at 2800 rpm in an IEC Damow centrifuge.

TABLE 4

BETA-GAMMA ACTIVITY IN PURGE EXHAUST
μCi

Date	Tank 16	Tank 15	HDB-2	
11/22-11/29/78	.06	.11	2.8	
11/29-12/6/78	.11	0.0	1.5	
12/6 -12/13/78	.19	30.0	7.2	First one-pump test slurrying and transfer
12/13-12/20/78	.11	1.03	20.0	
12/20-12/27/78	.076	.015	16.7	
12/27-1/3/79	.17	.033	12.2	Second one-pump test slurrying and transfer
1/3 -1/10/79	.14	.030	1.66	
1/10 -1/17/79	0	.054	3.48	
1/17 -1/24/79	.25	.20	2.93	
1/24 -1/31/79	.23	.018	1.83	
1/31 -2/7/79	.047	.148	4.98	First multipump test slurrying and transfer
2/7 -2/14/79	.101	.015	1.21	
2/14 -2/21/79	.136	.024	1.34	
2/21 -2/28/79	.072	.009	2.60	
2/28 -3/7/79	.153	.081	7.22	Second multipump test slurrying and transfer
3/7 -3/14/79	.386	.018	1.16	
3/14 -3/21/79	.260	.022	3.54	
3/21 -3/28/79	.130	.004	.87	
3/28 -4/4/79	.05	.07	3.2	

TABLE 5

AIR PURGE SYSTEM DATA

Multipump Test No.	1	2
Condenser		
Air inlet temperature, °C	28	38
Air flow, cfm	471	453
Water inlet temperature, °C†	27	27
Water flow, gpm	70	60
Vapor exit temperature, °C*	30	42
Tank vacuum, inches W.C.	.13	.13
Tank relative humidity, %	65	80

†Temperature rise of water through condenser was smaller than accuracy of thermometers.

*Air passes through steam jacket after the condenser before temperature is measured. Ventilation system on tank 16 is shown as Figure 8.

TABLE 6

SRL SLUDGE SETTLING MEASUREMENTS

Slurry	Hours of Slurrying	Rate of Settling, inches/hour*
2nd one-pump	23	.05
	43	.04
	130	.04
	179	.04
	204	.02
1st multipump	26	.002
	50	.02
	50	.01
	122	.01
	160	.01
	171	.01

*Based on 19 hours of observation.

TABLE 7

TRANSFER DATA FOR TANK 16 DEMONSTRATION

	One Pump Tests		Multipump Tests	
	1	2	1	2
Tank 16 Transfer Pump				
Transfer Rate (gpm)				
Throttled	100[2]	Note 1	~150[2]	94[3]
Unthrottled	120	192	203	182
Overall	110	192	160	160
Transfer Pump Amps	3-6.0	4-5.9	5.3-5.5	4.5-5.0
Seal Water Rate (Rotameter)	1.6	1.5-1.9	1.5-2.1	1.2-2.0
Seal Water Pressure (psig)	-	33	28-34	34
HPT-4 Transfer Pump				
Transfer Rate (gpm)	100-130	172	150	191
Transfer Pump Amps	30	30	-	25
Agitator Amps	-	10	-	10
Transferred Slurry				
Density (g/ml)	1.35	1.36	1.32	1.28
Viscosity				
RPM				
5	3500	400	1360	100
10	1850	250	750	60
20	975	140	400	50
50	440	70	190	30
100	250	55	110	29

[1]Not throttled.
[2]Throttled to keep pace with HPT-4 pump.
[3]Throttled to reduce pump heel.

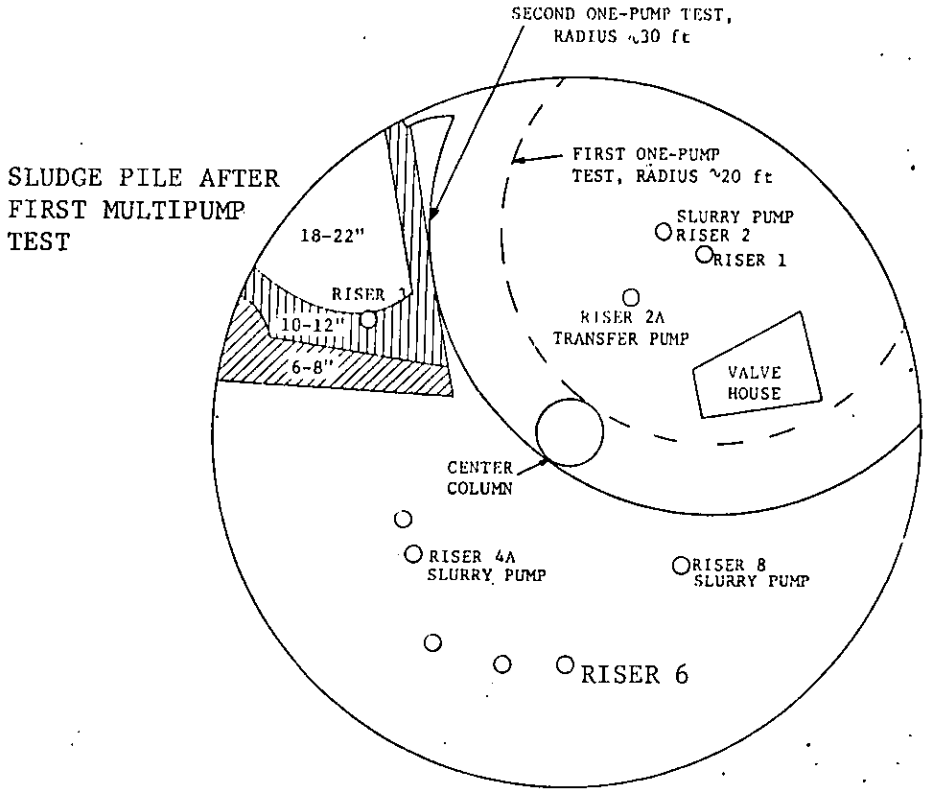


FIGURE 1. TANK 16 SLURRY PUMP DEMONSTRATION

FIGURE 2. TEMPERATURE VERSUS TIME - FIRST MULTIPUMP TEST

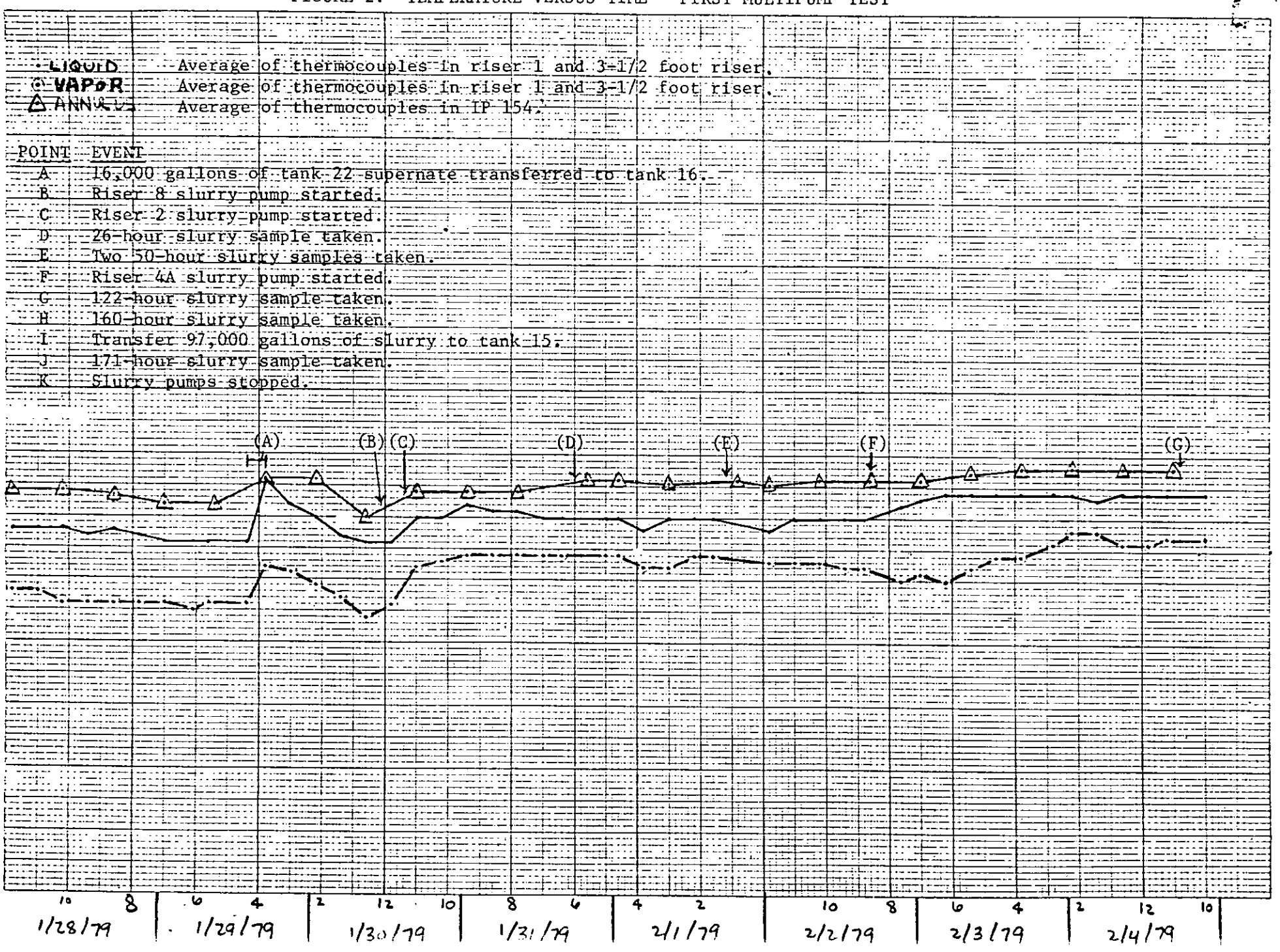


FIGURE 2 (continued)

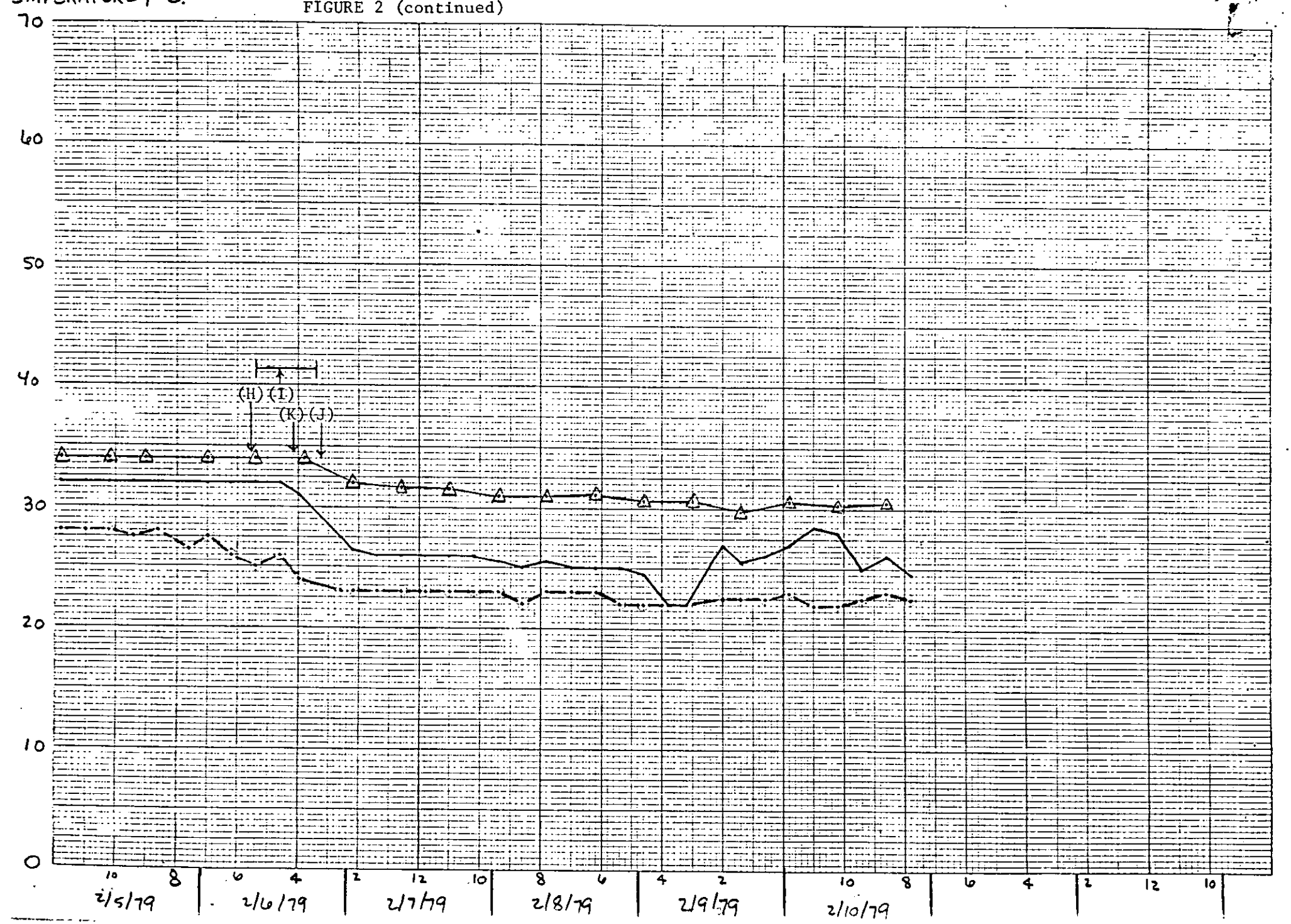


FIGURE 3. TEMPERATURE VERSUS TIME - SECOND MULTIPUMP TEST
(COOLING COILS OFF)

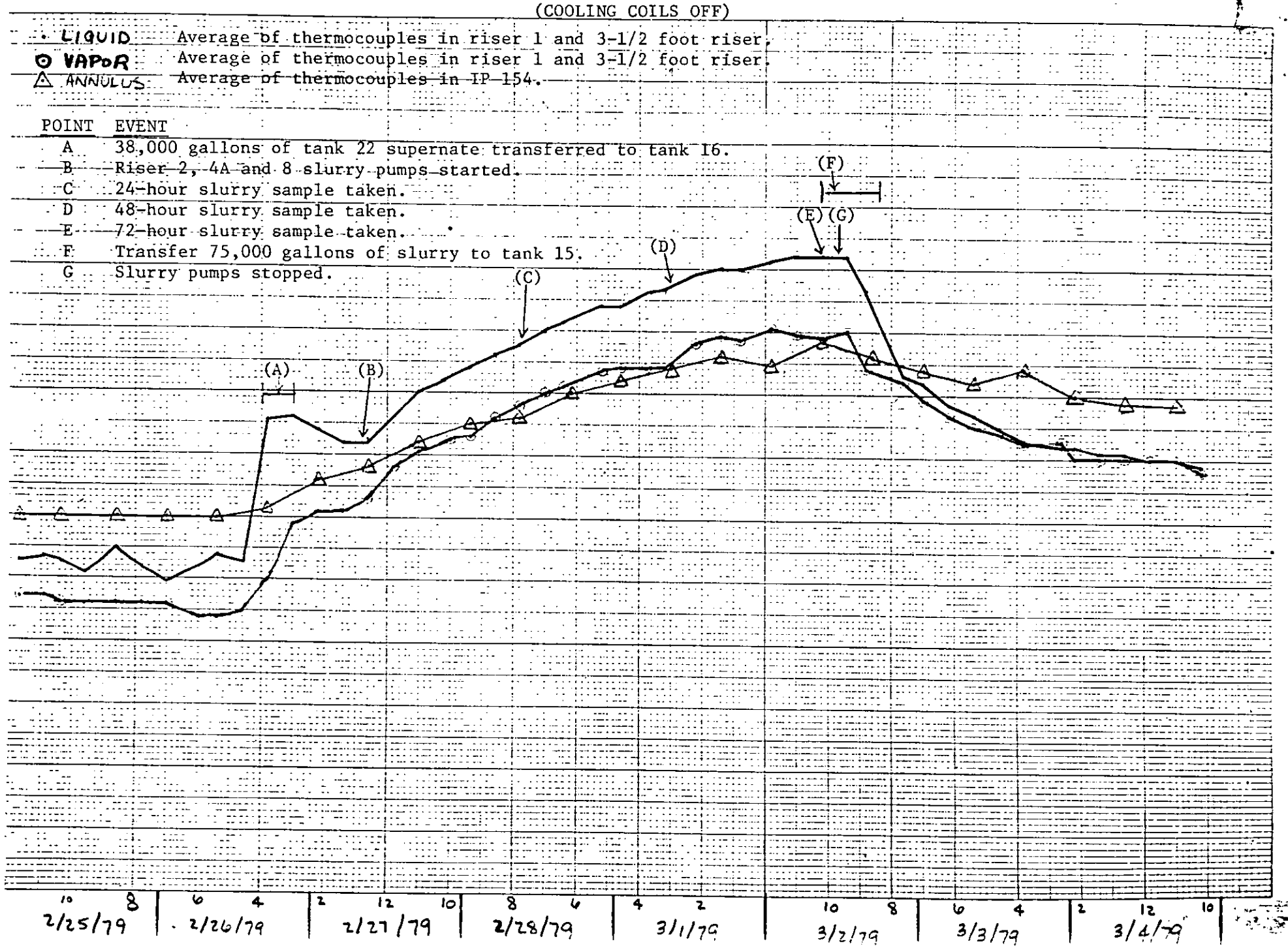
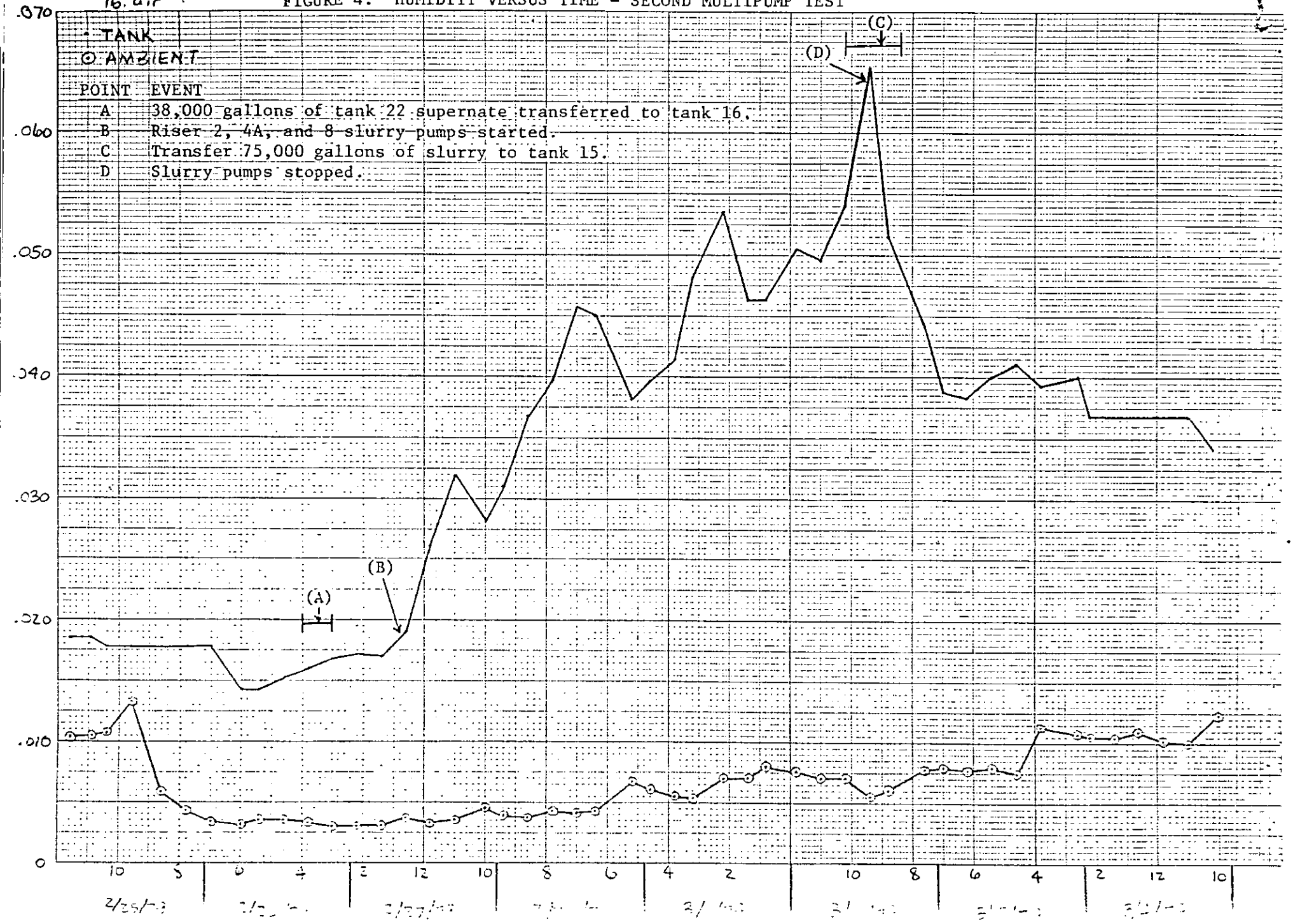


FIGURE 4. HUMIDITY VERSUS TIME - SECOND MULTIPUMP TEST



DPSP 79-17-17

FIGURE 5. CESIUM-137 IN GROUND WATER AROUND TANK 16 SAMPLED AT RISER 5

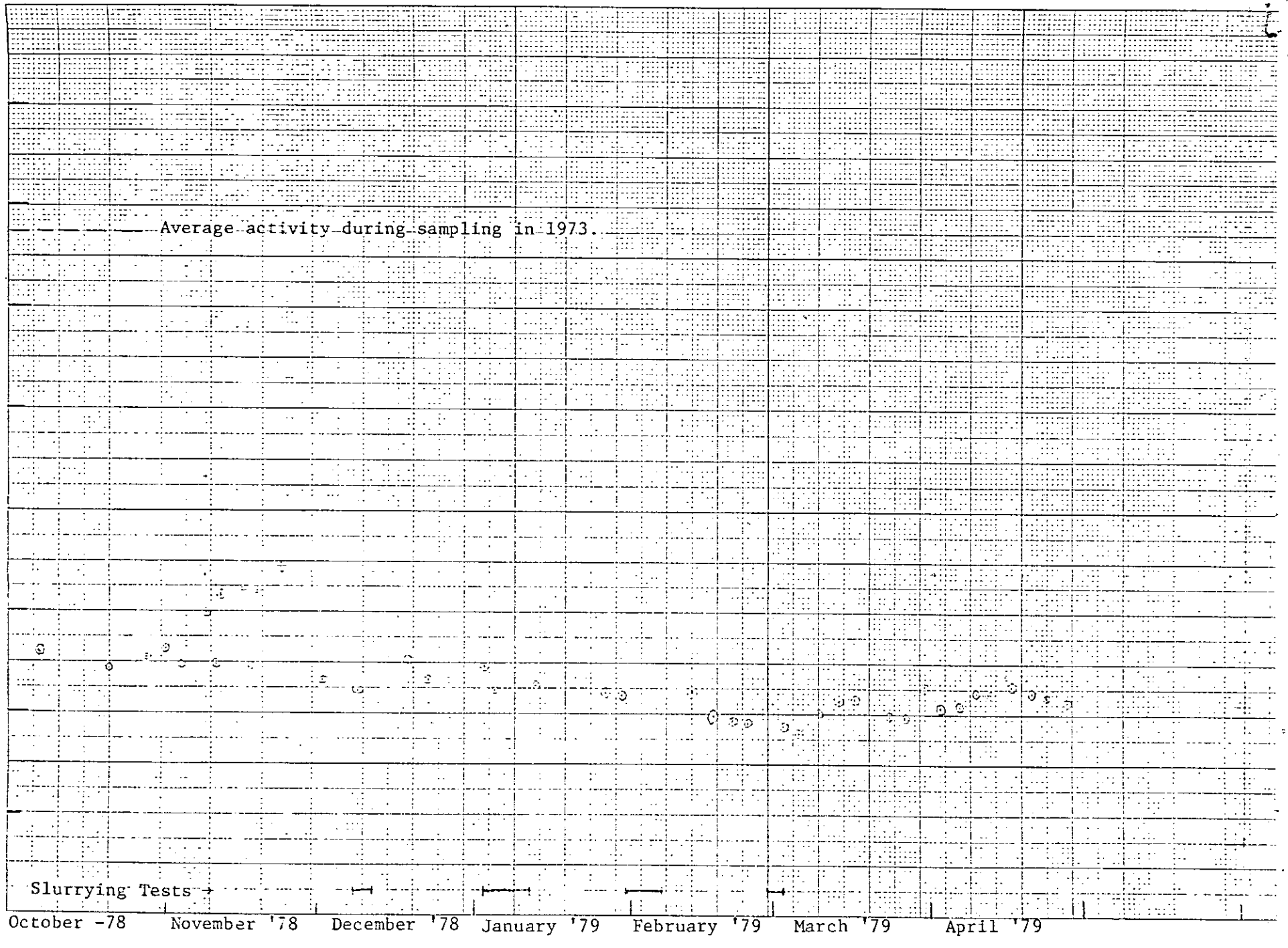


FIGURE 6

RADIATION PROFILE TANK 16 TRANSFER PUMP AND LINE TO HPT-4
FOR FIRST MULTIPUMP TEST

KEY

Letter	Reading mR/hr at 2"	Comment on Where Taken
A	150	At cover of transfer pump.
B	65	Top of valve box.
C	10	Top of lead shielded line.
D	10	Top of lead shielded line.
E	20	Top of lead shielded line.
F	25	Top of lead shielded line at bend.
G	300	Unshielded concrete next to line.

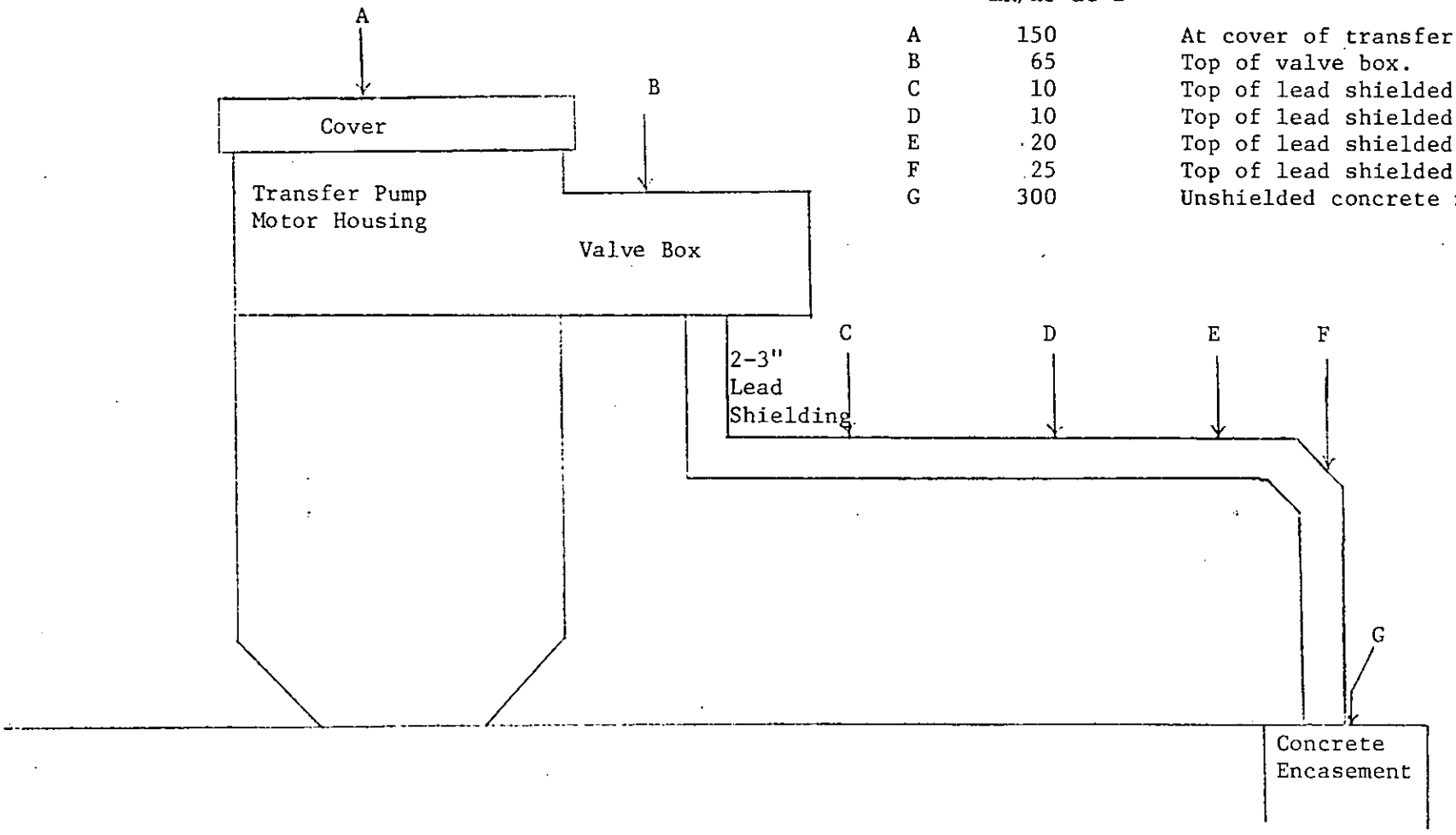


FIGURE 7

RADIATION READINGS ON SLURRY PUMP REMOVED FROM TANK 16

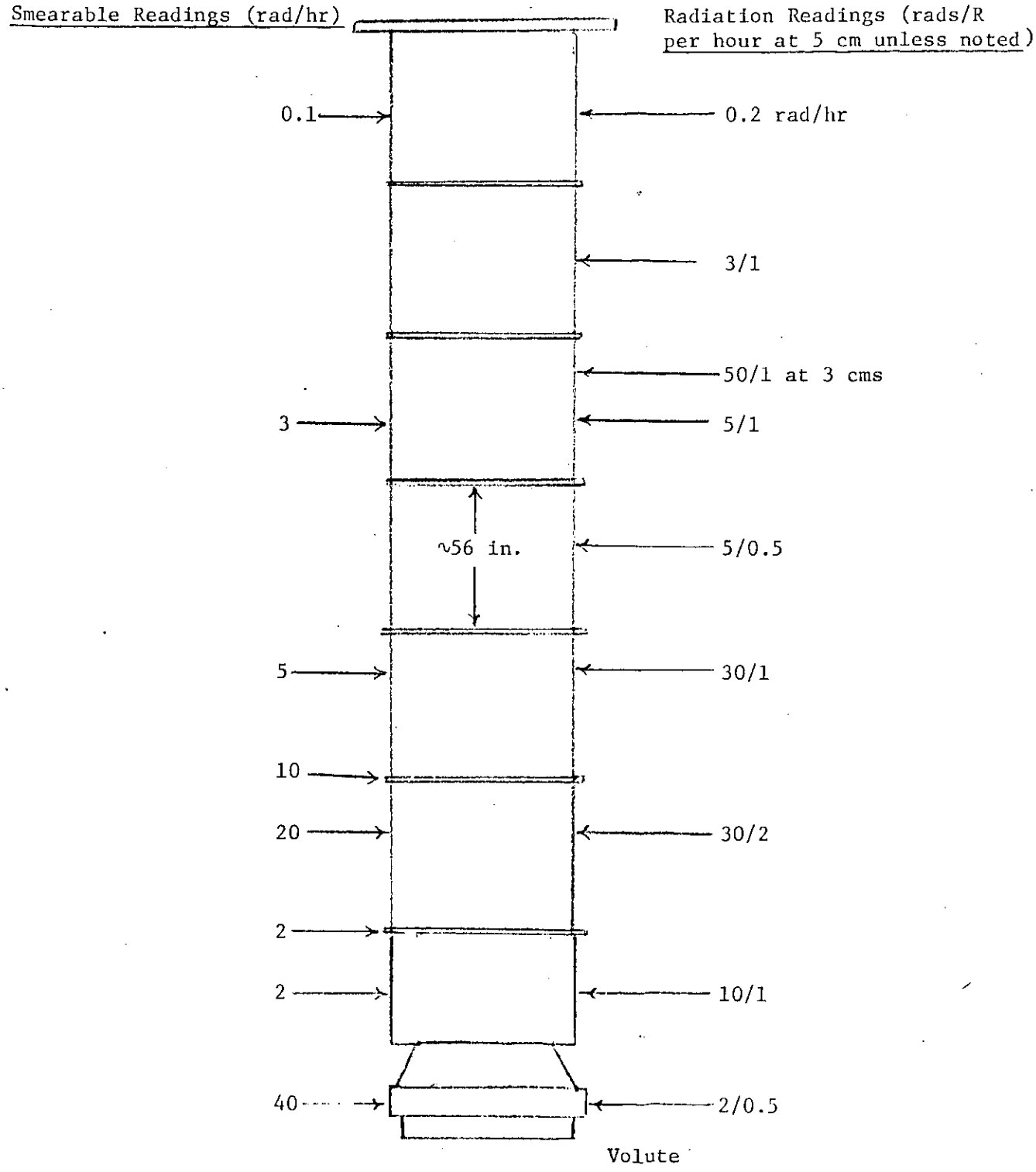


FIGURE 8

TANK 16 HEATING AND VENTILATION SYSTEM
(SSK-5-2-3256, SSK-5-2-3388, SSK-5-2-3141)